Answer to referee #1

Reviewer's recommendation: minor corrections

This manuscript examines the relationship between burnt area and wind speed over the Mediterranean region and Eastern Europe. The paper presents a quite extensive piece of work and deserves publication in NHESS. However, I think some improvements (minor revision) could be implemented before publication.

We thank the referee for his/her report and careful reading of our manuscript. The referee asks for several clarifications and modification, and below we carefully answer his/her questions and indicate how we take his/her suggestions into account. We hope that with these changes made, the paper will be accepted for NHESS. In the following, the comments of the referee are in red, our reply in black letters.

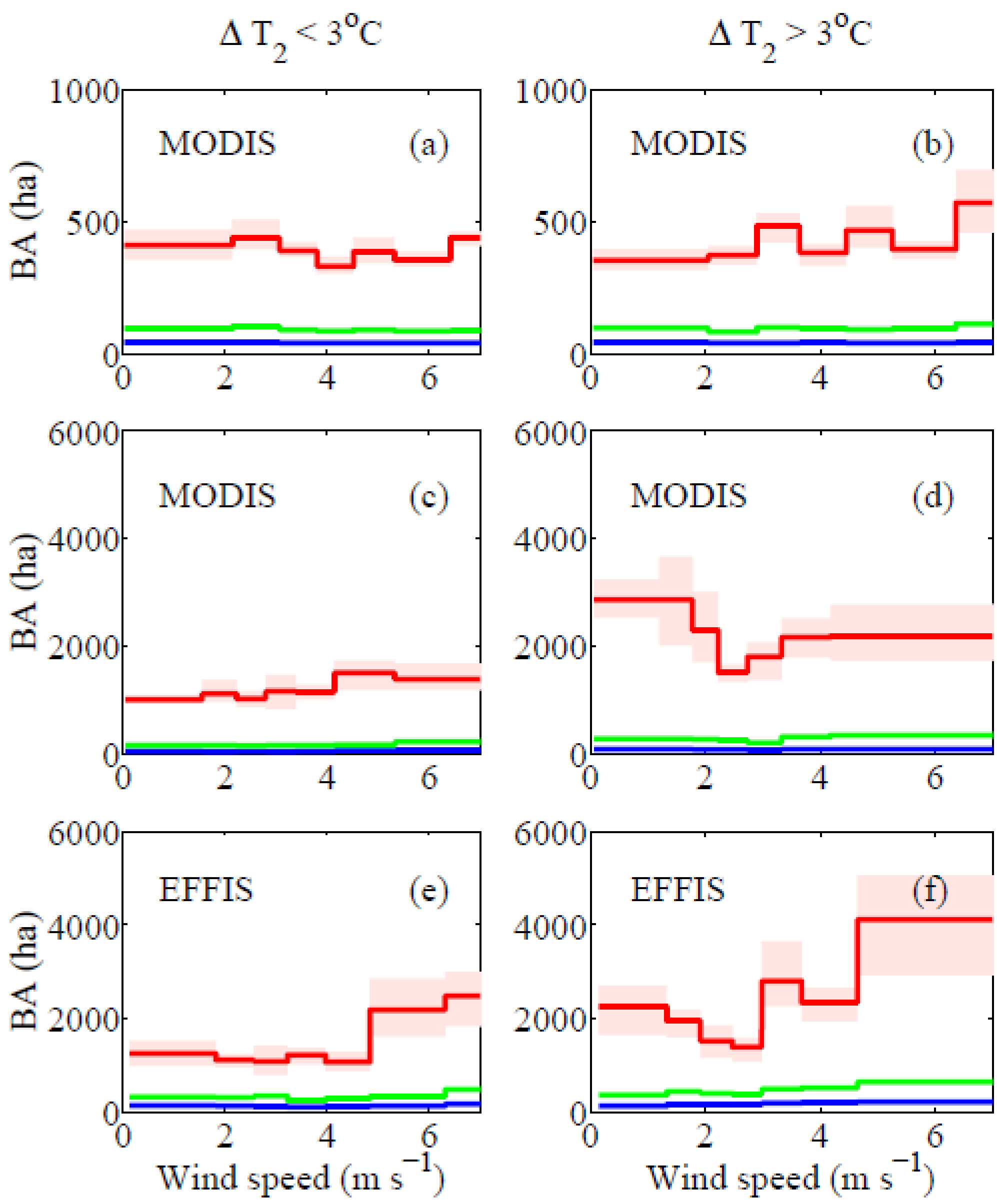
Some general comments

1. My main concern is about statements concerning the robustness of the results, especially in view of the uncertainties in observations and in the complex relation-ship between fires and other factors (e.g. environmental and socio-economic). Somehow, I feel that this uncertainty is not sufficiently assessed and acknowledged, which results in perhaps overly confident statements. The results might be more convincing if the uncertainties of the data and methods used were deeper analysed, or at least better discussed.

We agree with the referee and we now provide a more in-depth analysis of the uncertainties (see subsection 2.3). To do so, we:

1. compared the MODIS and the EFFIS products over the common region. A similar behavior of the burnt area with respect to temperature anomaly and wind speed is found with EFFIS dataset (see revised figure 2 below)
2. performed an analysis on several sub-domains as suggested by the referee (see below). Even though statistically less robust, a similar behavior is also found over different sub-domains
3. provided the confidence level of our data analysis. Our results are valid at the 70% confidence level (see revised figure 2 below).

The use of the PCA models is finally used as a theoretical tool which allows to support and explain the cause of such behavior.



Here is a list with some suggestions:

(a) It would be appropriate to better clarify whether this manuscript focuses on the analysis of the link between wind and fires, or in the discussion/evaluation of the fire model PCA. In addition, an example of how this model performs could increase confidence in the results.

In this article we present some different behaviors of the burnt area with respect to the surface wind speed. We then use the PCA model to give a theoretical framework to explain the observed variations of the burnt area of the largest fires with respect to wind speed (and temperature anomaly). In our revised manuscript we modified the introduction to make the objectives of the paper clearer. In particular, in place of " Our study relies on the following data-driven observation: under certain circumstances wildfires tend to decrease in size with small wind speed. In order to investigate this assessment we will perform a theoretical study of percolation threshold in PCA with varying wind speed using the modelling framework shown on Alexandridis et al. (2008)" we write " Our study relies on the following data-driven observation: under certain circumstances wildfires tend to decrease in size with moderate wind speed. A possible cause of such behavior is sought by simulating with a PCA model the fire propagation with varying wind speeds.”

(b) Showing and discussing the similarities and/or differences between the MODIS and EFFIS datasets, where available, could increase confidence in the data used.

In the submitted manuscript we wrote by mistake that we used the MCD45 fire product for our study. In fact we use a modified version of the MCD64 product, taking into account the methodology developed by Turquety et al. (2014). The horizontal resolution of the pixel is 25 ha, and the uncertainty of the detection can be high if only one single pixel is detected burnt. However, there is no lower bound for the size of the detected wildfires in the dataset, since only the fraction of the pixel covered by vegetation is considered as burnt, which can thus be small. This has been corrected in our revised manuscript. We now also use the EFFIS data set in our revised article. . It is provided by the Joint Research Center of the European Commission, and is built using MODIS images at 250 m horizontal resolution. A first step of automated classification is used to isolate fire events and a post-processing using human visualization of the burnt scar is performed. A cross-analysis using the active fire MODIS product, fire event news collected in the EFFIS News module as well as land-cover datasets is finally done to ensure a low number of misclassifications (http://forest.jrc.ec.europa.eu/effis/). The system records burnt areas of approximately 40 ha and larger (Sedano et al. 2013). In our study, the area of the shape of the wildfire is the burnt area and the location of the wildfire, the centroid of its shape. The EFFIS data sets includes fires smaller than 40 ha but the uncertainty for these wildfires is higher. In order to provide additional proof of the differences in the behavior of BA, we modified figure 2 so that the 95 th quantile of burnt area derived from the EFFIS dataset is also. The revised figure 2 show similar results with MODIS and EFFIS datasets (see figure above). This was included in our revised manuscript.

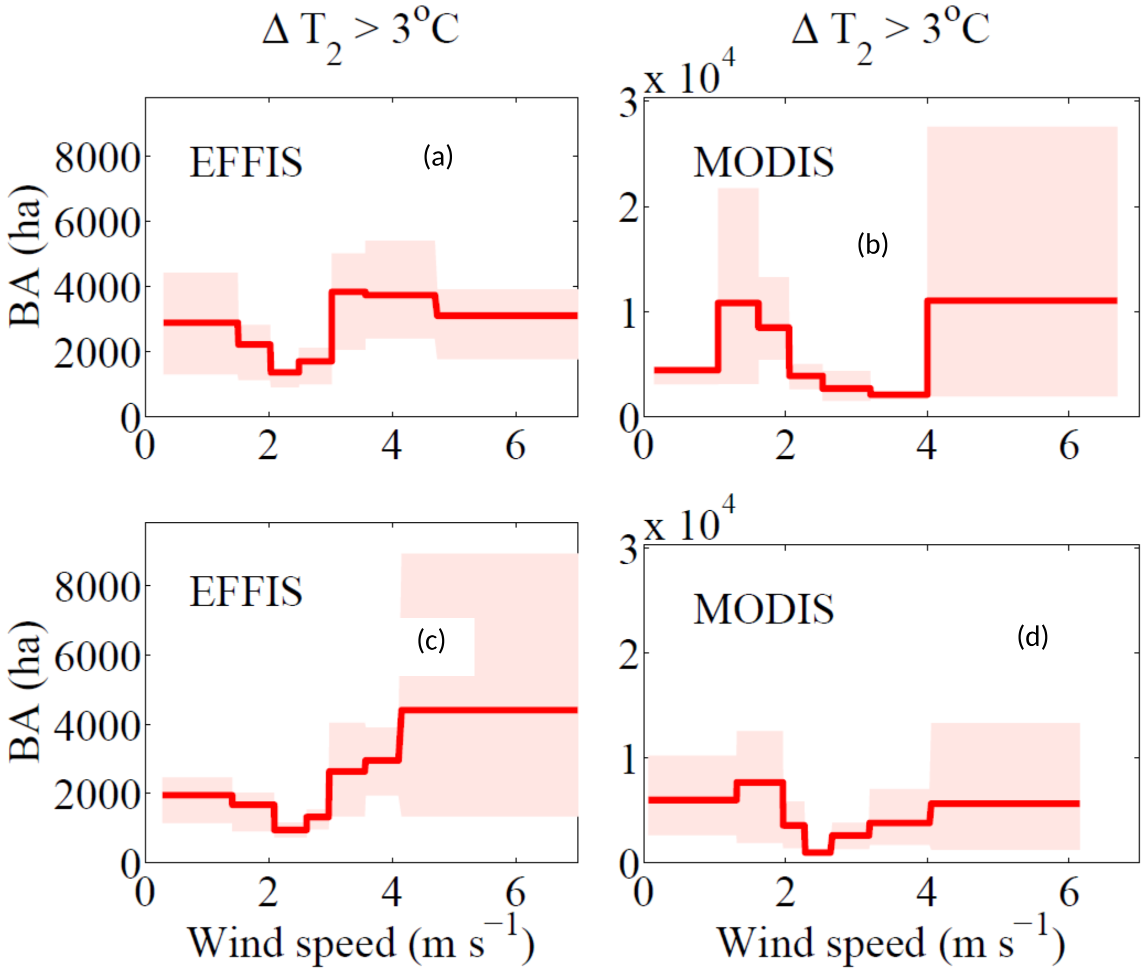
Sedano, F., Kempeneers, P., San-Miguel-Ayanz, J., Strobl, P., and Vogt, P., 2013: Towards a pan-European burnt scar mapping methodology based on single date medium resolution optical remote sensing data. *Int. J. Appl. Earth Obs. and Geoinformation*, **20**, 52-59.

(c) The complex weather-fire relationship need to be better discussed, especially considering potential confounding factors (e.g. changes in fire fighting or ignitions over the years). In particular, fires have a large seasonality (generally there are more fires in summer in Mediterranean regions) and the fire drivers may change during the year. An analysis aggregating the data for season could shed light on this issue.

We forgot to say that we only analyze wildfires detected in July and August. As suggested by the referee there are more fires in summer in the Euro-Mediterranean region. They are also the largest and that is why we focus on those wildfires only. We made that clear in the revised manuscript (subsection 2.1): “Because the drivers of the wildfires can change over the course of the year, and because the largest wildfires occur in summer, we only consider wildfires detected in July and August”.

(d) MED and EAST are very different, also in terms of surface. Have you tried to analyse sub-areas of the MED domain?

The figure below shows the variations of the burnt area (EFFIS and MODIS data sets) for two different regions of the Mediterranean Basin, Iberia (upper row) and northern Algeria (bottom row). The left column corresponds to the EFFIS data set and the right column to MODIS. In red is the estimated value of the 95 th quantile of BA and in shaded pink the associated 70% confidence interval.



Although being less illustrative, this figure shows patterns similar to what is found over the whole Mediterranean region. When ΔT2 > 3°C, the burnt area decreases with increasing wind speed and then increases after a wind speed threshold around 2-3 m/s (in the ERA-I reanalysis). If we number the bins 1 to 7 from left to right, we see in the panel b of the figure that bins #4, #5 and #6 are significantly lower than bin #3. Bin #6 is also significantly lower than bin #7. We see in panel d the same pattern, with bin #4 being significantly lower than all other bins. Similar analysis can be made in panels a and c with the EFFIS dataset. However, in the revised version, we did not add this figure but mention the result.

2. The authors do not give proper credit to relevant previous works that have analysed the weather and/or climate relationship with fires in similar regions (see the section references for several examples).

We thank the referee for his/her suggestions of references. Most were added to the reference list of the revised manuscript.

3. The results are often discussed in reference to “heatwaves and droughts”, although the authors do not analyse droughts. I suggest removing the reference to drought or, in addition to wind and temperature, also analysing some drought indices.

The occurrence of heatwaves is generally associated with preceding droughts as discussed in Vautard et al. (2007) and Stéfanon et al. (2012). However, since the main focus of the article is not on droughts (the temperature anomaly has a strong signal on wildfires while the situation of drought is generally a background situation in summer in the Mediterranean), we removed the reference to drought in the revised article.

Some specific comments

1. ABSTRACT: I think that the abstract is not easy to understand for a wide and diversified audience. If possible, please rewrite, or briefly explain, the "cellular automation model" and the "percolation threshold".

Clarifications were added to the revised abstract. We write "To explain such behavior we use a stochastic model of fire propagation, known as a probabilistic cellular automaton. This model uses a probabilistic local rule to derive the total burnt area" and "The observed relationship between burnt area and wind speed can be interpreted in terms of a percolation threshold above which the propagation in the model is infinite, which mainly depends on local terrain slope and vegetation state (type, density, fuel moisture)."

2. TITLE. I think that the title does not reflect the main contents of the paper.

We think the problem was more that the article was not clear about its main purpose. Now that it is clarified the title fits the main contents of the paper.

3. P 1204 L 25. I do not understand why there is a reference to boreal areas.

This reference to boreal areas was removed in the revised manuscript. Following the referee's comments, we now focus on the Mediterranean region.

4. P 1205 L 4. Please use more recent references (e.g. San-Miguel-Ayanz et al. 2013, Ganteaume et al. 2013).

We added these references.

5. P 1205 L 5-11. This part is not clear. I think that the year 2003 was one of the most severe in Portugal in terms of fire activity. I do not know if it was also severe in other European countries (e.g. is 800'000 ha above the average in Mediterranean Europe?) and the cited reference is still not available. The fire drivers may also need deeper discussion. Please re-write and include published references.

Vegetation fires burnt an average 200,000 ha annually in the Mediterranean Basin between 1960 and 1970; the figure attained over 400,000 ha in the 1970's and over 600,000 ha in the 1980's. This threefold increase over 20 years is turning into an annual summer-catastrophe in the Basin (Le Houérou, 1987). The 2003 wildfires of Portugal are a good example of the amount of damage that large wildfires can cause in the Mediterranean region. To make this part of the introduction clearer, we re-wrote it as follows:

"The Mediterranean basin is also the major European region where wildfires occur, with about 90% of the European burnt area (Chuvieco, 2009). Vegetation fires burnt an average 200,000 ha annually in the Mediterranean Basin between 1960 and 1970; the figure attained over 400,000 ha in the 1970's and over 600,000 ha in the 1980's (Le Houérou, 1987). Indeed, it increased ten-fold between the 1873-1972 time period and the following three decades (Pausas and Fernandez-Muñoz 2011). Between 1980 and 2003, 57 % of the total burnt area and 38 % of all ignited fires in Europe burned in Portugal (EFFIS, 2003). The main cause of this trend of Mediterranean wildfires has been attributed to rural depopulation, inducing an increase in fuel amount and causing a change of fire regime from fuel-limited to drought-driven (Pausas and Fernandez-Muñoz 2011) . Large wildfire occurrence is also affected by special weather conditions which do not affect most of other fires (Alvarado et al., 1998)."

Le Houérou, H. N., 1987: Vegetation wildfires in the Mediterranean basin: evolution and trends., *Ecologia Mediterranea*, **13**, 13-24

6. P 1205 L 12-P1206 L4. The discussion on the fire drivers could be improved by including citations on studies in Europe (see "Reference" for some suggestions). Specifically, please include some references for the past evolution of forest fires in Mediterranean regions (see e.g. Koutsias et al 2013; Turco et al 2013b; Fréjaville and Curt, 2015), for the climate/weather-fire relationship (see e.g. Pausas 2004; Thonicke et al 2010; Moreira et al 2011 for a review; Pausas and Paula 2012; Bedia et al 2013; San-Miguel-Ayanz et al 2013; Turco et al. 2013b; Lecina-Diaz et al. 2014; Loepfe et al 2014) and climate change impacts (see e.g. Batllori et al 2013; Turco et al 2014).

The referee is correct and we therefore added the following paragraph in our introduction: "Fire occurrences in the Mediterranean region are driven by human (e.g. land use) and environmental (e.g. weather and topography) factors (Ganteaume et al 2013). The synoptic weather conditions favorable to Mediterranean wildfires are either blocking (Pereira et al 2005) or trough (Levin and Saaroni 1998). Temperature anomalies (Bedia et al 2014) and summer droughts (Dimitrakopoulos et al 2011) are also critical to explain fire occurrence in the Mediterranean Basin. On longer time scales, the aridity level is also linked with large fire occurrence (Pausas and Paula, 2012). In Greece, Koutsias et al (2013) found a positive correlation between 2 years lagged precipitations and burnt area. This climatic driving of burnt area will be impacted by climate and land cover changes. In particular the combination of several factors including rural depopulation and increased fire frequency due to rising temperatures in southern Europe could lead to a general change in the dominant vegetation species, with a predominance of shrublands over forested areas (Moreira et al 2011). Other studies suggest that the change in fire regime will be different whether the climate shifts towards warmer-drier (less fire activity) or warmer-wetter (more fire activity) conditions in the Mediterranean Basin (Batlori et al 2013), a question which remains unanswered."

7. You could change Silva et al. (2010) with Ganteaume et al. (2013).

We added Ganteaume et al (2013) to the references.

8. P 1206 L12. Why has the influence of precipitation not been analysed?

Summer precipitations are very weak in the Mediterranean basin and so the drought signal is a background signal for summer Mediterranean climate. Conversely, the temperature anomaly (i.e. heatwave occurrence) has a much clearer and direct correlation with fire occurrence (Pereira et al., 2005; Bedia et al 2014). Such temperature anomaly are associated with anticyclonic weather conditions which favor the absence of precipitation (Stéfanon et al 2012). The link with aridity level is found at longer time scales which is not the time scales under investigation in this study. Indeed, the link between heatwave occurrence and preceding spring precipitation deficit has been shown by Vautard et al. (2007) and Stéfanon et al. (2012). Even longer time scales can be at stake (Koutsias et al., 2013). Therefore, in this study, only the direct effect of temperature anomaly and wind speed intensity are analyzed. Precipitation deficit is only mentioned as a collateral effect.

9. P 1206 L5-24. The objective of this study is not outlined clearly. In addition, the authors do not indicate clearly their contribution with reference to previous and/or related work.

This study furthers the work of Cardil et al (2014) on the link between temperature anomalies and wildfires and the work of Pausas and Paula (2012) and Loepfe et al. (2014) on threshold effects in wildfire propagation (e.g. threshold on aridity level) by analyzing the influence of wind speed on burnt area. We made that clearer in the introduction and discussion of the revised version.

10. P 1207 L 19. How do you compare the MODIS and meteorological data, since they are at different resolutions?

We take the ERA-Interim nearest grid point from each wildfire. In order to clarify our methodology we added the following sentences to subsection 2.2. " To relate the ERA-Interim meteorological data with the fire products, the ERA-Interim data are extracted at the grid point closest to the wildfire. The ERA-Interim reanalysis is the only homogenized gridded dataset at the Euro-Mediterranean region scale available with wind speed information. It is relevant to provide the large-scale environment in the vicinity of the wildfire. Wind speed data at finer resolution would probably add value to refine the relationship between wind speed and wildfire, especially in terms of wind speed range (which is probably underestimated with the ERA-Interim dataset)."

11. P 1208 L 9-11. Repetition. I think this sentence can be deleted.

Corrected.

12. P 1209 L 6. I think that a figure with this information could be added in the revised version of the manuscript.

Figure 2 was modified to also show the dependence of EFFIS wildfire products and wind speed and temperature anomaly.

13. P 1209 L1. Are there similar results in other regions/studies?

The line reference does not seem to relate to the comment. We cannot answer the referee's comment since a dedicated work would be necessary since to our knowledge no similar studies have been published. A natural follow-up would be to extend this study to other hotspots of wildfire activity (Australia, USA), which we propose in the conclusion of our revised manuscript.